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INFLUENCE OF HUMAN URINE-COMPOST MIXTURE ON SOME SOIL FERTILITY PROPERTIES, YIELD AND SHELF-LIFE OF TOMATO (*Solanum lycopersicon*)

ABSTRACT

Human urine, especially if combined with composts, could be a good source of fertilizer for improving soil fertility and ultimately, crop production. Thus, the focus of this investigation was to evaluate the influence of human urine-compost mixture on post-harvest soil fertility quality, yield and shelf-life of tomato (*Solanum lycopersicon*). The investigation which was a field experiment and had six treatments was conducted at the Department of Agronomy, Faculty of Agriculture and Forestry, University of Ibadan, Oyo State, Nigeria. The six (6) treatments were: 100% Urine, 100% Compost, and 2/3 compost + 1/3 urine, 1/3 compost + 2/3 urine, NPK 15:15:15 and the control (no soil additive) laid in a Randomized Completely Block Design (RCBD) with four replicates. The experimental plots had received the same treatments continuously for the past six (6) years. The fertilizer treatments were applied at the rate of 90 kg K/ha and the effects on soil fertility status, number of fruits, fresh and dry weights, as well as shelf-life were observed using tomato as the test crop. The 100% urine treated soils had the highest ($P<0.05$) number of fruits (16.50 fruits/plant) at the end of the first planting. At the end the second planting, urine treatment had the highest mean dry weight of 141 kg/ha, while NPK 15:15:15 resulted into the lowest yield (70 kg/ha). Generally, the use of human urine and urine-compost mixtures as fertilizers improved the soil fertility status, yield and shelf-life of the tomato fruits. Thus, human urine in combination with either 1/3 or 2/3 compost nitrogen is recommended as alternative to mineral fertilizer (NPK) for Tomato production.

Key words: Tomato, *Solanum lycopersicon*, human urine, fertilizer, soil fertility, wastes management

Introduction

In several communities of the world, improper disposal of human urine continues to be a menace, contributing to environmental hazards and disease infections. Toxics elements such as nitrogen dioxide (NO_2) and ammonia (NH_3) in this waste contaminate the environment and

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aquatic bodies, causing reasonable disorders. The presence of ammonia in untreated urine release into the atmosphere causes stench. However, human urine can be treated and converted to valuable agricultural uses; human urine contains plant nutrients which are cheap and readily available, useful for improving soil fertility and increase food production [15; 21]. Useful potential of similar human waste–excreta has been documented. According to Wolghast (1993) (30), the annual amount of human excreta of one person corresponds to the amount of fertilizer needed to produce 250 kg of cereal that one person needs to consume per year; thus it is possible to have good quantity of human urine as fertilizer [18] for crop production. Adewole *et al.,* 2013 [4]; AdeOluwa and Sobamowo, 2008 [3] elucidate that acceptability of urine as a fertilizer is a way of increasing farmers' gross margins. Positive impact was also reported with maize [9; 23; 24].

Organic fertilizers are sourced from organic wastes which contain large organic matter and have advantage over synthetic fertilizer [14]. Examples of organic fertilizers are compost, green manure, animal manure, other agricultural wastes, plant and human waste (excreta, and urine), etc. Cofie *et al.,* 2010 (12); AdeOluwa and Cofie, 2012 [2] stated that human urine was successfully used to raise some crops like amaranths, celosia, lettuce, carrot, etc. There is an increasing research interest in the fertilizer value of human waste with studies focused mainly on the yield potentials [24]. Thus, there was the need to evaluate the effects of human urine on tomato.

Tomato (*Solanum lycopersicon*) is one of the most important vegetable worldwide. It belongs to the family Solanaceae, with total world production of 159 million tonnes in a cultivated area of 4.7 million hectares and an average yield of 33.6 tonnes/ha [13]. Nigeria is ranked 16th on the global tomato production scale, and this accounts for 10.8% of Africa and 1.2% of total world production (5). Tomato is rich in minerals, vitamins, essential amino acids, sugars and dietary fibres. It contains a high level of antioxidants such as vitamin C, polyphenols (including flavonoids) and carotene (such as lycopene and ß-caroten) [16]. Tomatoes could be processed into purees, juices, ketchup, canned and dried. Human urine, compost and their mixture have been found useful as sources of fertilizers, thus the main objective of this work was to evaluate the influence of human urine-compost mixture fertilizers on postharvest soil fertility quality, yield and shelf-life of tomato fruits.

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Materials and methods

The experimental site was situated at the back of Department of Agronomy, University of Ibadan, Ibadan, Oyo state. The experimental plots (a long term trial with human urine fertilizer) have received the same fertilizer treatments continuously for the past six (6) years prior to this experiment and planting was done twice. The soil was loamy sand, slightly acidic to slightly alkaline, low in nitrogen, moderate in organic carbon and potassium. The materials for the experiment included: tomatoes seeds (Roma VF), Compost, NPK 15:15:15, urine (harvested from Obafemi Awolowo hall of residence, University of Ibadan, Ibadan, Nigeria and stored for 6 months in air tight plastic containers before use [29]. The experiment was laid in Randomized Completely Block Design (RCBD) with four replicates as shown below:

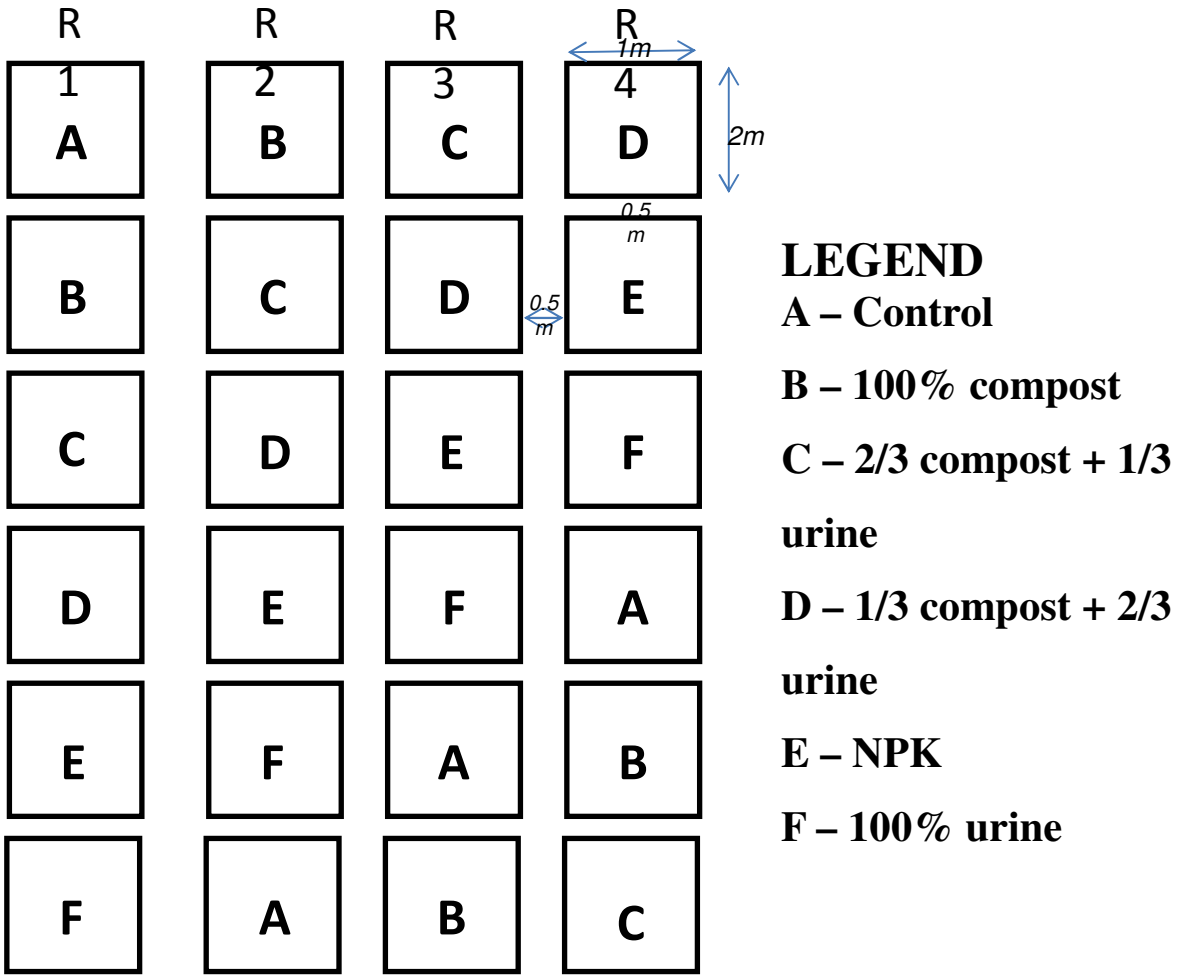

Fig. 1: Experimental design Layout

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Agronomic study

The planting was done in two successions between May, 2012 and June, 2013 during raining seasons. Land clearing was done manually and this was followed by seedbed preparation. Each experimental bed was 2 m by 1 m with 0.5 m spacing in between the beds. There was a total of 24 experimental plots and land area of 79.75 m^2 (14.4 m x 5.5 m), transplanting of tomato seedlings was done at four weeks after sowing at the spacing of 60 cm x 40 cm with twelve (12) plants per plot. The fertilizer treatments were applied at the rate of 90 kg K/ha and in a two split using spot application. The compost was applied one week before transplanting, while urine and NPK 15:15:15 fertilizer was applied at two days before transplanting. The second application was done at the on-set of flowering of tomatoes, that is, two weeks after transplanting. Weeding was done manually as at when due with cutlass. Data were collected at 2, 4 weeks after transplanting. Composite soil samples per experimental plot were collected at 0-15 cm depths randomly for chemical and physical soil analysis. The soil samples were air-dried and sieved using 2mm for routine analysis. Particle size distribution was determined by hydrometer as cited by Tel and Hargaty (1991) [26] using sodium hexametaphosphate (calgon) as the dispersing agent. Soil pH was determined using distilled water (at ratio1:1) electrode ELL pH meter. Organic carbon was determined using dichromate wet oxidation method and value of organic matter was obtained by multiplying the Organic carbon value by a factor of 1.724. Total nitrogen was determined by macro Kjeldahl procedure. Available phosphorus was determined by Bray and Kurtz[10] method and determined colourimetrically using Molybdenum blue Method, while K, Ca, and Mg were first extracted using neutral normal (NH_40Ac), thereafter K was determined by flame photometry, and Ca by spectrophotometry, using the atomic absorption spectrophotometer. Micronutrients (Mn, Fe and Cu) were extracted with Mehlich extractant and determined with Atomic Absorption Spectrophotometer (AAS).

Crop production parameters observed were number of fruits, fresh weight of yield (t/ha), dry weight (kg/ha), and shelf-life (number-of-days to 50 and 100% deterioration). The data obtained were subjected to analysis of variance (ANOVA) and the means were separated using least significant difference (LSD) at 5% level of significance [25]. Data on shelf-life (days) were analyzed based on Mondal's method [19].

Results

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Pre-planting chemical properties of the experimental soil

Table 1 shows the chemical properties of the soil before the commencement of the experiment. The result revealed that the pH of the plots ranged from 6.3 - 7.4. This implied that the soils were slightly acidic to slightly alkaline. The NPK plot had the lowest pH at first planting (6.3) and at the second planting, the pH was 6.7. The organic carbon of the experimental plots at the first planting ranged from medium to high (15-23.22 g/kg), with the control plot having the highest value (23.2 g/kg), closely followed by 100% compost plot (21.7 g/kg). The lowest value (14.9 g/kg) was obtained from NPK plot. All the treatments were high in organic carbon except the NPK treated soil, which was medium. At the second planting, the values of organic carbon ranged between 0.4-2.1 g/kg, with 100% compost plot having the highest value. At the first planting, all the experimental plots had total nitrogen in the range of 0.4-1.4 g/kg. The highest total nitrogen value was observed from 2/3 compost + 1/3 urine plot (1.4 g/kg) and the lowest value in NPK plot (0.4 g/kg). At the second planting, all the experimental plots had low nitrogen (0.1 - 0.2 g/kg) with 100% urine plot having the highest value. At the first planting, the exchangeable K values of the plots ranged from medium to high (0.3 - 0.9 cmol/kg). The plots with 1/3 compost+2/3 urine (0.4 g/kg) and the control (0.3 g/kg) were medium in exchangeable K. At the second planting, all the plots were low in exchangeable K. At the first planting, extractible Fe in the experimental soil resent was at medium range with values (60-105 mg/kg). The plot of 100% compost had the highest Fe (105 mg/kg), while that of 1/3 compost+2/3 urine had the lowest (60 mg/kg). At the second planting, the extractible Fe in the soils were 72-105 mg/kg with the plot of 100% urine having the highest (105 mg/kg) and 2/3 compost+1/3 urine plot having the lowest (72 mg/kg). Extractible Mn content of the experimental soils ranged within low to medium (58 – 104 mg/kg). The control plot had highest value (104 mg/kg), while the 1/3 compost+ 2/3 urine plot had the lowest (58 mg/kg). At the second planting, the reverse was the case with 1/3 compost+ 2/3 urine plot having the highest value of 84 mg/kg Mn and control plot the least (71 mg/kg). Therefore, the experimental soils were low in nitrogen, moderately low in organic carbon and moderate to high in potassium at beginning of the planting seasons.

Effects of applied treatments on soil nutrient properties

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The soil pH before commencement of the experiment (first planting) was slightly acidic to slightly alkaline: control (7.0), 100% compost (7.4), 2/3 compost + 1/3 urine (7.3), 1/3 compost + 2/3 urine (7.3), NPK 15:15:15 (6.3) and 100% urine (7.2). At the end of the first planting, 100% urine, 2/3 compost + 1/3 urine and 1/3 compost + 2/3 urine plots had reduced pH from 6.5 to 6.8, 6.6 to 7.3 and 6.4 to 7.1 respectively (Table 4). The soil organic matter was also increased in the treated plots; the urine plot had the highest organic carbon of 3.1 kg^{-1} at the end of second planting. The plot with 1/3 compost + 2/3 urine treatment had the highest total nitrogen value (2.8 g/kg) which is above the critical range of 1.5 - 2.0 g/kg [13].

Table: 1 Pre-planting chemical properties of the soil

Treatment	pH	O.C	N	P	K	Ca	Fe	Mn	Cu
		g/kg		mg/kg		cmol/kg		mg/kg	
1st Planting									
Control	7.1	23	0.5	21	0.3	3.1	97	104	1
100%C	7.4	22	1.2	24	0.9	2.8	105	97	1
2/3C+1/3U	7.3	19	1.4	17	0.6	2.7	98	87	1
1/3C+2/3U	7.3	19	0.8	19	0.4	2.1	60	58	0
NPK	6.3	15	0.4	14	0.7	2.8	88	95	2
100%U	7.2	21	1.2	21	0.6	2.6	90	95	1
Mean	7.1	19.83	0.92	19	0.6	2.7	90	89	1
SD	0.40	2.86	0.41	4	0.2	0.3	16	16	1
2nd Planting									
Control	7.0	1.3	0.1	27	0.2	2.9	90	71	2
100%C	7.1	2.1	0.1	36	0.2	4.9	95	81	2
2/3C+1/3U	6.9	1.3	0.1	15	0.1	4.4	72	82	1
1/3C+2/3U	6.6	0.4	0.1	20	0.2	3.8	95	84	2
NPK	6.7	0.4	0.1	16	0.2	2.9	85	79	2
100%U	6.6	1.7	0.2	24	0.1	3.1	105	78	2
Mean	6.8	1.20	0.12	23	0.2	3.7	90	79	2
SD	0.2	0.69	0.04	8	0.1	0.8	11	5	0

SD: standard deviation

Legend:

100% C: 100% compost

2/3C+1/3U: 2/3 compost + 1/3 urine

1/3C+2/3U: 1/3 compost + 2/3 urine

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100%U: 100% urine

Table: 2 Post-Planting chemical properties of the soil

Treatment	pH	O.C	N	P	K	Ca	Fe	Mn	Cu
		g/kg		mg/kg		cmol/kg		mg/kg	
1st Planting									
Control	6.6	11.6	2.2	36	0.3	3.7	568	467	5
100%C	6.5	14.3	1.9	37	0.4	3.5	706	578	5
2/3C+1/3U	6.6	12.8	2.2	34	0.4	3.3	698	479	6
1/3C+2/3U	6.4	11.3	2.8	24	0.3	2.4	613	379	4
NPK	6.5	10.2	2.1	33	0.5	3.2	640	516	5
100%U	6.5	9.9	1.7	31	0.3	3.7	545	483	4
Mean	6.5	11.7	2.2	33	0.4	3.3	628	484	5
SD	0.1	1.7	0.4	5	0.1	0.5	66	65	1
2nd Planting									
Control	7.0	1.6	0.1	30	0.2	4.4	100	77	1
100%C	7.4	1.6	0.1	48	0.5	11.0	214	90	1
2/3C+1/3U	7.3	1.1	0.1	28	0.3	4.1	152	88	1
1/3C+2/3U	7.1	1.1	0.2	28	0.4	3.9	149	87	1
NPK	6.9	1.3	0.1	38	0.2	11.7	242	95	1
100%U	6.8	3.1	0.1	51	0.2	10.7	175	105	2
Mean	7.1	1.6	0.1	37	0.3	7.6	172	90	1
SD	0.2	0.8	0.0	10	0.1	3.9	51	9	0

SD: standard deviation

Legend:

100% C: 100% compost

2/3C+1/3U: 2/3 compost + 1/3 urine

1/3C+2/3U: 1/3 compost + 2/3 urine

100%U: 100% urine

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Response of tomato to urine and its compost mixtures

The result of the yield parameters (Table 3) revealed better performances of the organic fertilizer sources on the plant, compared to the mineral fertilizer (NPK). At the end of the first planting, the 100% urine produced the highest significant (P<0.05) number of fruits (16.50/plant) and the least number of fruits (3.25/plant) was recorded in the control treatment. At the end of the second planting, 2/3 compost + 1/3 urine had the highest number of fruits (17.4/plant), while the least was recorded in the control treatment (3.07/plant).

Similarly, at the end of the first planting, the 2/3 urine + 1/3 compost treatment resulted into the highest significant (P<0.05) mean dry weight (834 kg/ha) and the control plots (no soil additive applied) recorded the lowest yield mean dry weight (149 kg/ha). The 2/3 compost + 1/3 urine treated plots had the highest significant (P<0.05) mean fresh weight 246 g/fruit (13 t/ha). At the end of second planting, urine treatment had the highest significant (P<0.05) mean dry fruit weight (142 kg/ha), while the NPK plot had the lowest (25 kg/ha). The 1/3 compost + 2/3 urine treated plant had the highest fresh fruit weight (1.76 t/ha) while the lowest fresh fruit weight was recorded by NPK and the control (0.5 t/ha).

The results of the effects of fertilizer treatments on shelf-life of tomato fruits is shown in Table 4. At days-to-50% deterioration, the treatments with compost and 2/3 compost + 1/3 urine (37.3 days) performed better compared to NPK (13.3 days) and the control (11 days) at the first planting. Similar trend was recorded at the second planting.

Table: 3 Effects of treatments on number of fruits, the fresh and dry weight of tomatoes

Treatments	Number of fruits (fruits/plant)	FW (t/ha)	DW (kg/ha)
1st Planting			
Control	3.25	1.81c	148.85d
100%C	13.75	5.85b	273.61cd
2/3C+1/3U	13.75	13.22a	611.11b
1/3C+2/3U	14.2	11.83a	834.56a
NPK 15:15:15	8.25	5.74b	377.29c
100%U	16.5	2.30c	203.13cd
2nd Planting			
Control	3.07	0.49cd	69.58bc

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100%C	7.43	1.03b	74.38bc
2/3C+1/3U	17.44	0.81bc	95.83ab
1/3C+2/3U	4.00	1.76a	118.75a
NPK 15:15:15	3.31	0.54c	25.00d
100%U	4.57	0.60c	141.67a

Means with same letter(s) in a column are not significantly different by Duncan Multiple Range Test (DMRT)

*Means difference not significant at P<0.05

Legend: No significance at P<0.05

FW: Fresh fruit weight

DW: Dry fruit weight

Table: 4 Effects of treatments on the shelf-life of tomato fruits after harvest

Treatments	Days-to-50% deterioration	*Days-to-100% deterioration
1st Planting		
Control	11.0b	14.3
100%C	37.3a	46.3
2/3C+1/3U	37.3a	50.0
1/3C+2/3U	24.0ab	35.0
NPK	13.3b	32.3
100%U	14.0b	27.3
2nd Planting		
Control	18c	29
100%C	50a	112
2/3C+1/3U	45a	81
1/3C+2/3U	39ab	60
NPK	25b	52
100%U	35b	90

Means with same letter(s) in a column are not significantly different by Duncan Multiple Range Test (DMRT)

* No significant difference at P<0.05

SD: standard deviation

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Legend:

100% C: 100% compost

2/3C+1/3U: 2/3 compost + 1/3 urine

1/3C+2/3U: 1/3 compost + 2/3 urine

100%U: 100% urine

Discussion

Tomato (*Solanum lycopersicon*) is one of the most important vegetables worldwide. Thus, the focus of this investigation was to evaluate the fertilizer values of urine and its compost mixture on some soil fertility properties, yield and shelf-life.

Generally, the compost and 1/3 compost + 2/3 urine fertilizer treatments showed better residual soil fertility status compared to other treatments used this investigation, compared to that of mineral fertilizer NPK, based on the soil chemical status analysed. The better fertility status of most of the soils treated with compost and 1/3 compost+ 2/3 urine could be due to benefits of organic matter in the soil [30]. This was mostly evident with the results of organic carbon and nitrogen contents of the soils, Although, the pH of all the soils were at the end of the first planting period within the safe range of 5.5 - 7.0 [7] , however, this was not the same at the end of the second planting period. The average pH of the soil at this planting period was basic; especially with the compost and its urine mixtures. This could be the strength of these organic fertilizers to buffer soil pH during tropical raining season, when the soil could be more acidic, due to leaching of bases.

The agronomic observations revealed that the application of the 1/3 Compost+ 2/3 urine resulted in the better dry weight of fruits. Although the yields during the second planting were generally low, due to disease attack and bad weather, the 1/3 Compost+ 2/3 urine treatment still resulted into best yields (fresh and dry). This result could be attributed to the fact that nutrients in this treatment contributed to plants nutrients uptake. This result is in consonance with AdeOluwa *et al.,* 2009[1] who stated that nutrients in human urine are readily available as those mineral fertilizers. Similarly, this fruit yield (13.2 t/ha) at the first planting was higher compared to NPK (8.25 t/ha) and the average yield of tomatoes (10 t/ha) [6] in the southwest, Nigeria**.** The better

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performance of urine and urine-compost mixtures compared to mineral fertilizer is in agreement with the result of research findings of Nansabuga, [20] and AdeOluwa and Cofie (2012)[2] who reported that human urine has increased yield of some crops more than mineral fertilizers and also in Finland [8] where cabbage grown with human urine performed better than those from conventional plots. This result also corroborates previous experiments carried out by AdeOluwa and Sobamowo (2008) [3].

The better influence of the compost and 2/3 compost + 1/3 urine fertilizers generally improved shelf-life (50% to deterioration) of fresh tomato fruits. This could be due to better dry matter accumulation effect of these treatments in the tomato fruits [27]. The better shelf-life of the tomato fruits treated with organic fertilizers in this experiment could be due to better bioavailability nutrient supplied by the treatments [31].

In summary, the results of this investigation revealed that compost and urine-compost mixtures are excellent materials for improving soil fertility, yield of tomatoes and its shelf-life. Moreover, it has been established that treated urine is safe for crop production [29].

Conclusion

The results of this investigation reveals that human urine could be a good fertilizer for producing tomatoes in terms of soil fertility for improvement, yield increase and improvement in shelf-life. Moreover, if the compost is combined with 2/3 urine nitrogen value, the effects are better. Consistently, the compost and urine-compost mixtures performed better than the commonly used NPK mineral fertilizer. This is an indication that if human urine is properly harvested and treated, it might no longer be a menace in many communities. Thus, the use of either 2/3 compost + 1/3 urine or 1/3 compost + 2/3 urine N mixture is recommended for production of tomatoes. Urine alone could also be used when there is no compost to mix it.

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